Fine Points on Tube Testing

by William E. Burke — *Consulting Editor, PF Reporter*

It is common knowledge that the majority of troubles in electronic equipment are caused by tube failures. This is especially true of television receivers. This would not be too bad if only the tube failures were clearly indicated by symptoms; repair would consist simply of replacing the proper tube or tubes. The situation is complicated, however, by the fact that a high percentage of tube failures are not self-evident; they masquerade as failures of other components.

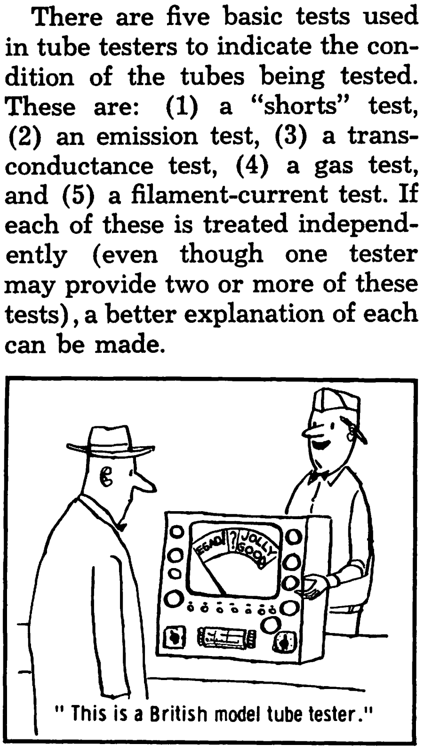
The VTVM and VOM are instruments bought and used by practically every service technician for the testing of components in television receivers. They are used to test resistors, capacitors, transformers, etc.; and their readings or indications are trusted and relied upon as guides to quicker servicing. If service technicians can implicitly trust such instruments, which only measure but do not judge conditions, they can surely buy and trust a tube tester with which to check tubes.

At this point, many service technicians will say, "I have a tube tester, and it's a pretty good one. But I don't use it because it tests some tubes as good when they won't work in a set." Such a situation probably exists in quite a few service shops. A considerable amount of money was expended on a tube tester, and it was used until the first or second time it led the service technician astray during a difficult repair. After that it was used only for testing tubes brought in by customers, or it was forgotten.

Most users of tube testers expect the instrument to be a judge of the condition of a tube and to be infallible in stating "bad" or "good." Their faith wavers when the tester proves otherwise. Actually, no tube tester can be 100% accurate in its indications, no matter what it costs; and, when cost is a prime factor, the quality and accuracy of the instrument has to suffer.

This decrease of accuracy of the tester itself, however, does not have to be detrimental to the accuracy of the results obtained by the operator. If the operator realizes the shortcomings of his instrument, he can allow for them and thereby get good service from the tester. A knowledge of the shortcomings of the various types of tube testers and a perusal of the instruction manual for your tester should help you efficiently use your tester and get a good return for the money you have invested in it. For those who have no tester at the present time, the information in these pages should serve as an argument for the purchase of one to suit your requirements. If you have a tester which is old and is only partly adequate for rapid and accurate tube testing, you should consider the purchase of a new one.

There are five basic tests used in tube testers to indicate the condition of the tubes being tested. These are: (1) a "shorts" test, (2) an emission test, (3) a transconductance test, (4) a gas test, and (5) a filament-current test. If each of these is treated independently (even though one tester may provide two or more of these tests), a better explanation of each can be made.



" This is a British model tube tester."

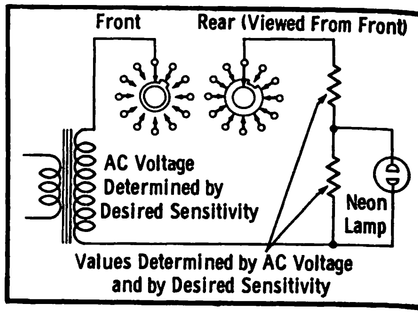


Fig. 1. Typical "shorts" test circuit.

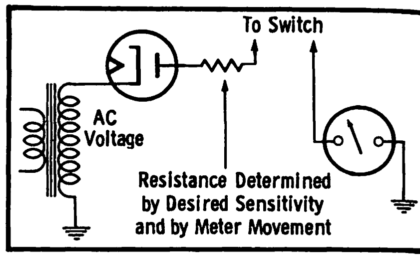


Fig. 2. Circuit for the measurement of interelectrode leakage.

Shorts Test

For the protection of the instrument, a "shorts" test of a doubtful tube should always be made first. It is possible for a tube to have an internal short which has not physically harmed the equipment in which it is used; yet the same tube might burn up the tube tester when checked for conductance.

The typical "shorts" test applies a voltage (usually AC) between each tube element and all the others as shown in Fig. 1. Any direct short or resistive path (leakage) between two elements will pass enough current to activate an indicator in series with the circuit. The less expensive instruments generally use a neon lamp as the indicator. A circuit of this type has one drawback in that series resistance must be used to keep the lamp from burning out when there is a direct short between two elements. This series resistance imposes a limit on the maximum resistive short that can be indicated to about one megohm.

There are circuits in which a leakage resistance of one megohm will have absolutely no effect. There are others in which a one-megohm leakage could disable the circuit and cause confusing symptoms. An IF amplifier tube with a leakage of one megohm between grid and cathode could cause AVC trouble symptoms. The more expensive testers get around this

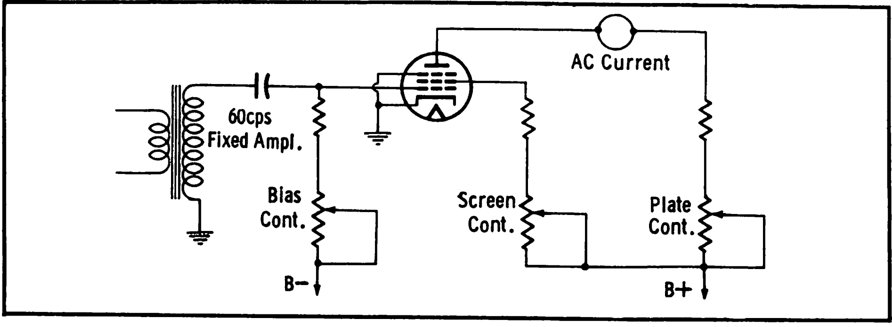


Fig. 3. Gm test-circuit hookup.

limitation by switching the "quality" meter into the "shorts" circuit as an ohmmeter. A considerably greater range of resistance measurements is obtained with this type of circuit (see Fig. 2).

One point to remember about any tube tester, whether it be expensive or not, is that it should have a "shorts" test. This is the most definite of all tests; when a tube checks shorted, it should definitely be discarded.

Emission Test

A vacuum tube is essentially an electron-emitting device, and without further knowledge, a person would suppose that a check of a tube's cathode emission would be a valid check of the tube. Up to a certain point, this is true; however, the proper operation of most tubes other than diodes depends more upon the control of the emitted electrons than upon their number. An emission check is not an entirely conclusive check, but it can be used to great advantage if interpreted properly.

It might seem that an emission check of a diode would be adequate because no grid is incorporated to control electron flow. Even for a diode, however, the emission test can be inadequate if it is not made under conditions which will draw practically all of the available electrons out of the cathode. Suppose, for example, an inexpensive tester were being used to check a 5U4G tube. For purposes of economy, the manufacturer of the tester may have used a power supply capable of drawing only 100 milliamperes of plate current (which is adequate for most tubes). The cathode (filament in the case of the 5U4G) might easily emit enough electrons to produce the 100 milliamperes of current, and the tube will check "good," but the emitting element might not provide enough electrons for the 150 or 200 milliamperes needed by the equipment in which the tube is used. This tube would not provide proper operation of the circuit, yet the tester indicated that it was a good tube.

On the other side of the argument is the fact that the emission checker can be useful and accurate. When such a tester shows a tube as being "bad," the indication usually can be trusted. A tube which does not have sufficient emission cannot operate properly no matter how well the grid controls the electron flow.

Mutual Conductance Test

Mutual conductance, often called transconductance and abbreviated as Gm, is a measure of the effectiveness of a tube as an amplifier; it is expressed as a change in plate current produced by a change in grid voltage. In the typical transconductance tester, a small alternating voltage is applied to the control grid and an AC meter is used to measure the resulting alternating plate current (see Fig. 3). This test is made under dynamic conditions which duplicate the circuit operation more closely than do the static conditions imposed upon the tube by an emission checker.

In a variation of this test, a high-frequency grid signal is used in place of the 60-cycle voltage obtained from the power supply. A tuned circuit extracts the amplified signal from the plate circuit and applies it to the meter. A greater accuracy in the Gm test and freedom from 60-cycle hum troubles is thus obtained.

Gas Test

A vacuum tube never lives up to its name because it can never have a perfect vacuum. Some gas is always present, originating from the element materials or leaking through the tube envelope. Gas molecules interfere with electron flow and, in more than minimum quality, can affect proper operation of the tube. A test for gas content is desirable because troubles due to gassy tubes are usually ambiguous and hard to find.

The control grid in a tube can at times become contaminated with some of the oxide material from the cathode and emit electrons after the tube heats up. This condition is referred to as grid emission and will exhibit symptoms similar to those obtained with a gassy tube. The gas test in a good tester should be able to indicate both of these conditions.

The gas test usually involves setting up the tester for a measurement of either emission or transconductance and then switching a high series resistance into the control grid circuit. The presence of gas or grid emission will cause grid current to flow, and the voltage drop across the resistance will cause the grid bias and the plate current to change. The tester manufacturer generally gives the maximum change allowable for a good tube.

Filament-Current Test

Tubes intended for use in series-string receivers require a new test that is being provided on many currently-made testers. This test constitutes a measurement of the current drawn by the filament when the rated voltage is applied. The operation of these tubes is critical with regard to the amount of power applied to the filament, and any decrease in current will affect their performance. A series-string tube should be discarded when the current drawn by the filament at its rated voltage is considerably different from the specified value.

Older testers used by many shops do not have provisions for this test. In view of the number of series-string receivers being made, the shop owner should consider purchasing an instrument capable of making this test.

A comprehensive tester should provide for four of the five tests listed; either emission or transconductance plus all of the others. The point in question now is whether the emission or transconductance test is the best. This is determined in part by the circuit in which the tube is to be used. In the case of an RF or IF amplifier tube, the stage gain is proportional to the transconductance; thus the Gm test is the most important. In the case of an output or power rectifier tube, it must be capable of supplying large amounts of current; here, the emission test is most important.

A transconductance test must be made with the least possible amount of AC voltage on the grid for the most accuracy. Consider the case of a high-current triode such as those used for vertical-output stages. Such a tube must handle a grid signal of 100 volts and more, and therefore a transconductance test could hardly be accurate in telling you whether such a tube would work properly. No matter what tester is used, there are some tubes which cannot be checked completely and accurately. No tube tester provides the high voltage with which a 1B3GT should be tested. No tube tester tests UHF tubes at high frequencies.

Most technicians do and should rely on tube substitution in some cases. If you develop a technique which combines both testing and substitution, your servicing time is bound to be shortened. Every technician should develop his own set of rules to help him to determine whether he should test or substitute tubes. A typical set of rules might be:

1. When the receiver has one clear and distinct symptom, substitute tubes. This is quicker.
2. To partially insure yourself against callbacks, test all the tubes in a receiver before returning it. The bad or partially bad tubes you catch means increased sales as well as satisfied customers.
3. In the customer's home, substitute tubes. This is quicker.
4. When an older receiver is encountered, test all the tubes. This can prevent wasted time on difficult troubles due to more than one tube being bad.